University of Hawaii at Manoa

Hawaii Institute of Geophysics

MEMORANDUM

TO:
Mr. Minabu Tagomori
DOWALD/DLNR
1151 Punchbowl St. #227
Honolulu, Hi.

FROM:
Elizabeth A. Novak
Department of Geology and Geophysics
University of Hawaii
2525 Correa Rd.
Honolulu, Hi.

RE: Puna Geothermal Groundwater Monitoring Project

Dear Mr. Tagomori:

Enclosed you will find a progress report on my activities over the last six months.

The sample pumps mentioned in this report have been delivered to the Puna Research Center. We are now preparing to install them in five Puna area wells. One of these wells is Kapoho Shaft which is owned by the Hawaii County Board of Water Supply. The Board has asked that I submit a written request for access to this well. I have enclosed a letter to this effect which I would like to have you sign and subsequently be faxed to Hilo on DLNR letterhead stationary. If you have any questions on this matter please call me at my U. H. office, 956-8764.

Sincerely,

Elizabeth A. Novak

Elizabeth A. Novak

Progress Report for
Geochemistry Subtask
January 31, 1993

Objectives

The objectives of the geochemistry subtask are as follows:

1) Conduct monitoring and sampling of the shallow groundwater system in lower Puna to develop a baseline data base for the chemical and physical quality of the water prior to and during the planned development of the geothermal resource;

2) Provide independent analysis of geothermal fluids from all exploration wells that are drilled and tested during the commercial development of the geothermal resource;

3) Provide analyses of groundwater wells that are drilled in other areas of Hawaii where geothermal discharges are thought to exist in order to develop baseline data for the range of geothermal fluid compositions found in Hawaii.

Work Accomplished During Reporting Period 6/1/92 through 1/31/93

Groundwater Monitoring

In anticipation of the start-up of the monitoring program, water level monitoring equipment was ordered and five monitoring packages were received. The instrument packages consisted of water level, temperature, and conductivity measuring devices and a data logger that recorded these parameters at programmable intervals (one hour). Instrument packages were installed in Malama Ki well (see attached map for reference), the Kapoho Airstrip well, and GTW-3 (designated Puna Thermal 3 on map). Instrument packages were also to be installed in MW-2 and MW-3 but, because these wells were being used by PGV as chemical monitoring wells, we agreed to forestall installation of monitoring packages until we could also install a downhole pump to permit water sampling and continuous monitoring to occur simultaneously. Somewhat later in the monitoring period we were given access to an inactive well in Paradise Park, outside the rift zone, to use as a "reference well" with which to compare the results of our monitoring within the rift. A monitoring package was installed in that well in early September.

The results of the successful monitoring packages are presented in the attached figures. The salient points of the results are as follows:

1) There is a clear tidal signal present in all of the wells; this signal can be used to determine the permeability and storativity of the shallow groundwater aquifers and will be used in the groundwater modelling program;

2) There is a clear seasonal trend in the groundwater levels that is significantly higher than the tidal fluctuations; this signal

is the result of changes in rainfall recharge; there are significant differences between the timing of the water level changes in the wells in and south of the rift zone (Kapoho Airstrip and Malama Ki wells) and the "reference well" north of the rift; 3) Changes in water levels are correlated with changes in temperature and conductivity in all the wells; interpretation of these correlations is now underway.

Although the original requests for quotation for the instrument packages specified that the monitoring instruments would have to be able to withstand temperatures of up to 96°C, the instrument package installed in GTW-3 failed immediately after installation due to the high temperatures in this well. The instruments were returned to the manufacturer with a request to provide equipment as specified in the purchase order. The manufacturer has made modifications that should be able to correct the malfunction and has returned the instruments to us. We will be installing these instruments in the near future.

Groundwater Sampling and Analysis

The groundwater sampling and analysis program included all the accessible wells in the rift zone area. However, because the continuous monitoring packages prevented sampling without a downhole pump, routine sampling was only done for those wells that already had pumps installed (MW-1 and MW-3) or those that did not have monitoring packages downhole (GTW-3 and MW-2). Malama Ki well was sampled only when the instrument package was removed for repair.

A subset of the results of the sampling and analysis program are presented in the Figures 9 and 10. It is evident that the chloride concentrations in the wells are highly variable and ranges over a factor of more than 100. The most northerly of the shallow wells, MW-1 and MW-3, have the lowest chloride concentration whereas GTW-3 and Malama Ki, which are the hottest wells, have the highest chloride concentrations.

It is also apparent that there is temporal variability in the chloride concentrations in the individual wells. Because of the intermittent nature of the sampling, the variability is not as clear as that in the continuous monitoring effort. We believe that simultaneous monitoring for temperature, conductivity, and water level, along with sampling and analysis, will provide the clearest demonstration of the variability in the groundwater compositions.

With respect to the downhole pumps required for routine sampling, the depth and high water temperatures in some of the monitoring wells have caused considerable difficulty in obtaining equipment suitable for our needs. We have only recently been able to develop a design package for the downhole pumps and sampling equipment. A purchase order was issued in late December to acquire this equipment. As soon as we accept delivery, these pumps will be installed in our suite of monitoring wells on the east rift.

Analysis of Geothermal Fluids

The Kapoho State 8 well was in production during two periods in the second half of 1992 - during August and again in late October. During the first production test of KS-8, samples were taken for all major elements, a selected set of trace constituents and gas compositions, and for radon and carbon-14. Sample acquisition was more limited during the second production interval due to the unexpected termination of production from the well.

Because the sampling and analysis was conducted under the authority of DLNR, the data is being held as proprietary by Puna Geothermal Venture until they have completely analyzed the results of their own sampling effort. However, in general terms, the fluid compositions found in KS-8 were unique among those observed in other wells on the East Rift Zone. The steam quality was very high and the concentration of dissolved solids in the liquid fraction was much lower than had been observed up to the present time. The low concentration of dissolved solids would have made fluid disposal from that well much less difficult than would have otherwise been expected. The radon and trace metals analyses similarly indicated that the fluids posed a very low threat to the environment or to personnel with which they came in contact.

Analysis of Other Groundwater Wells

Our assistance has been requested for only one well test during the latter half of 1992. Samples were taken during a test of the Kawaihae Exploratory Well No. 6549-03. The results of our sampling and analyses indicated that:

1) Water temperatures were elevated slightly (~28.5°C or 83°F) in the water pumped from the well although the temperatures did not show a significant increase with time;

2) Chloride concentrations were somewhat higher than might be expected for a similar well at an equivalent distance from the coastline in some other locations;

3) The chloride to magnesium ion ratios and silica concentrations were elevated above those typically found for groundwater on the island of Hawaii.

Our initial interpretation is that the data are consistent with other groundwater data in the Kawaihae area that indicate the presence of a low temperature geothermal resource however, we are continuing to evaluate these data in an effort to better define the nature of the resource.

Future Work

Continuous monitoring of the groundwater wells will continue for the balance of the contract.

Installation of the recently modified monitoring packages is anticipated in the next three to four weeks.

Delivery of the sampling pumps is expected to occur within the next month to six weeks. As soon as they are received, they will be installed and tested in each of our monitoring wells.

Completion of KS-9 is anticipated in the next two weeks. We will conduct sampling of the fluids during the production test that is scheduled to occur after the well is completed.

Analysis and interpretation of the groundwater and geothermal data will continue as a collaborative effort with the groundwater modelling group.

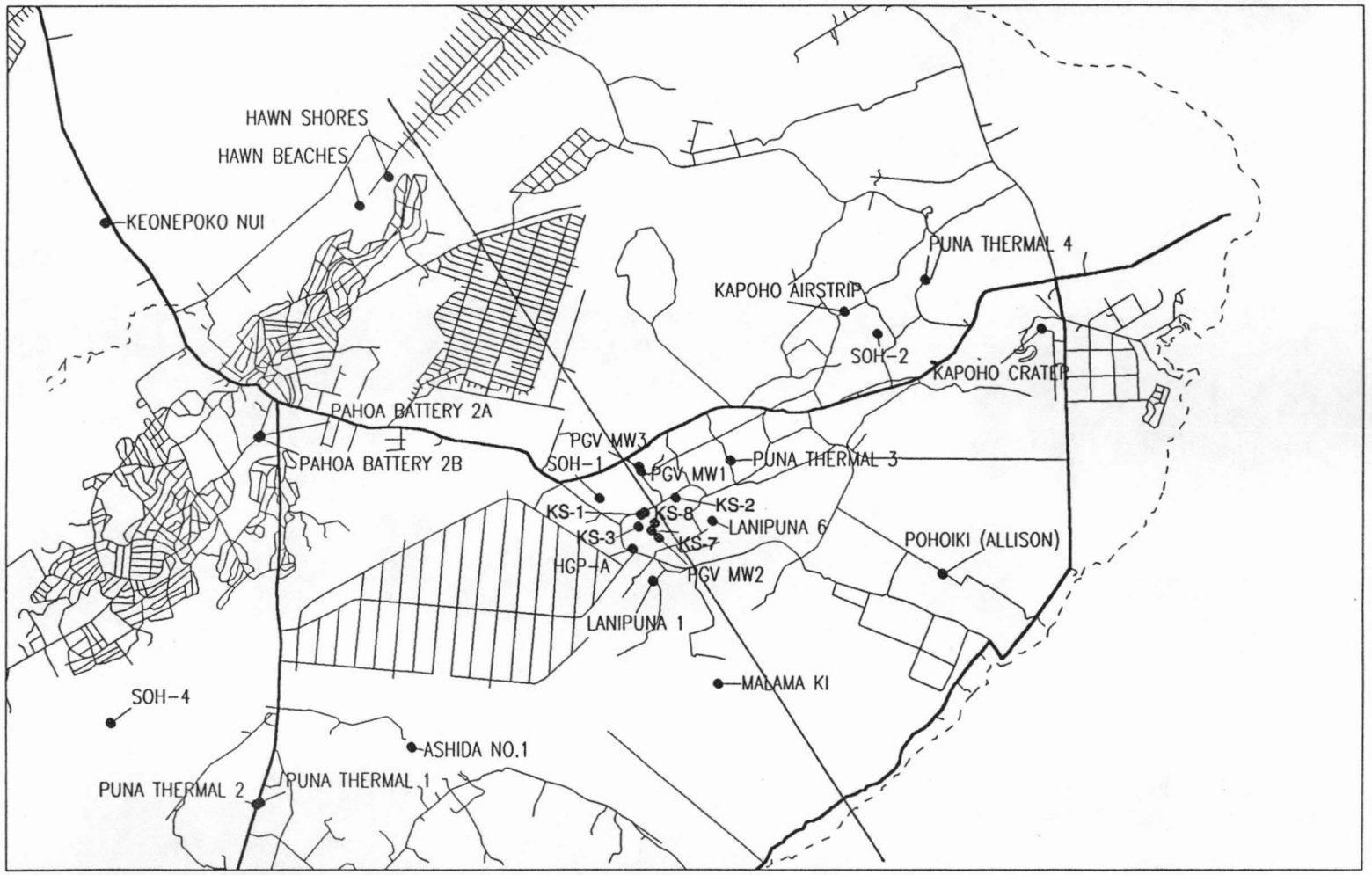
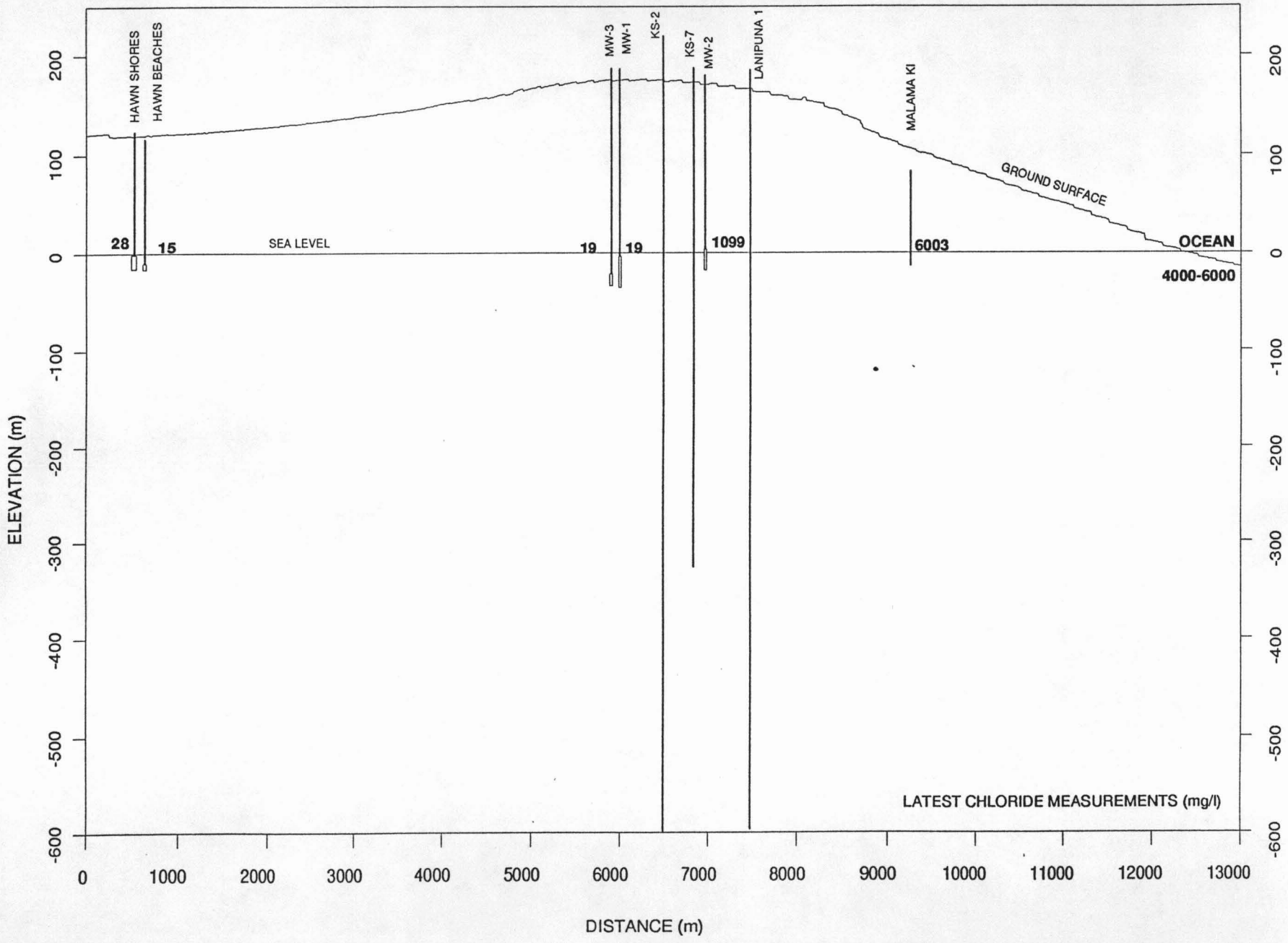


Figure 1. Location map of shallow and deep wells on the Lower East Rift Zone (Prepared by Groundwater Modelling Group).

Figure 2. Location and depth of selected wells on LERZ (Prepared by Groundwater Modelling Group).



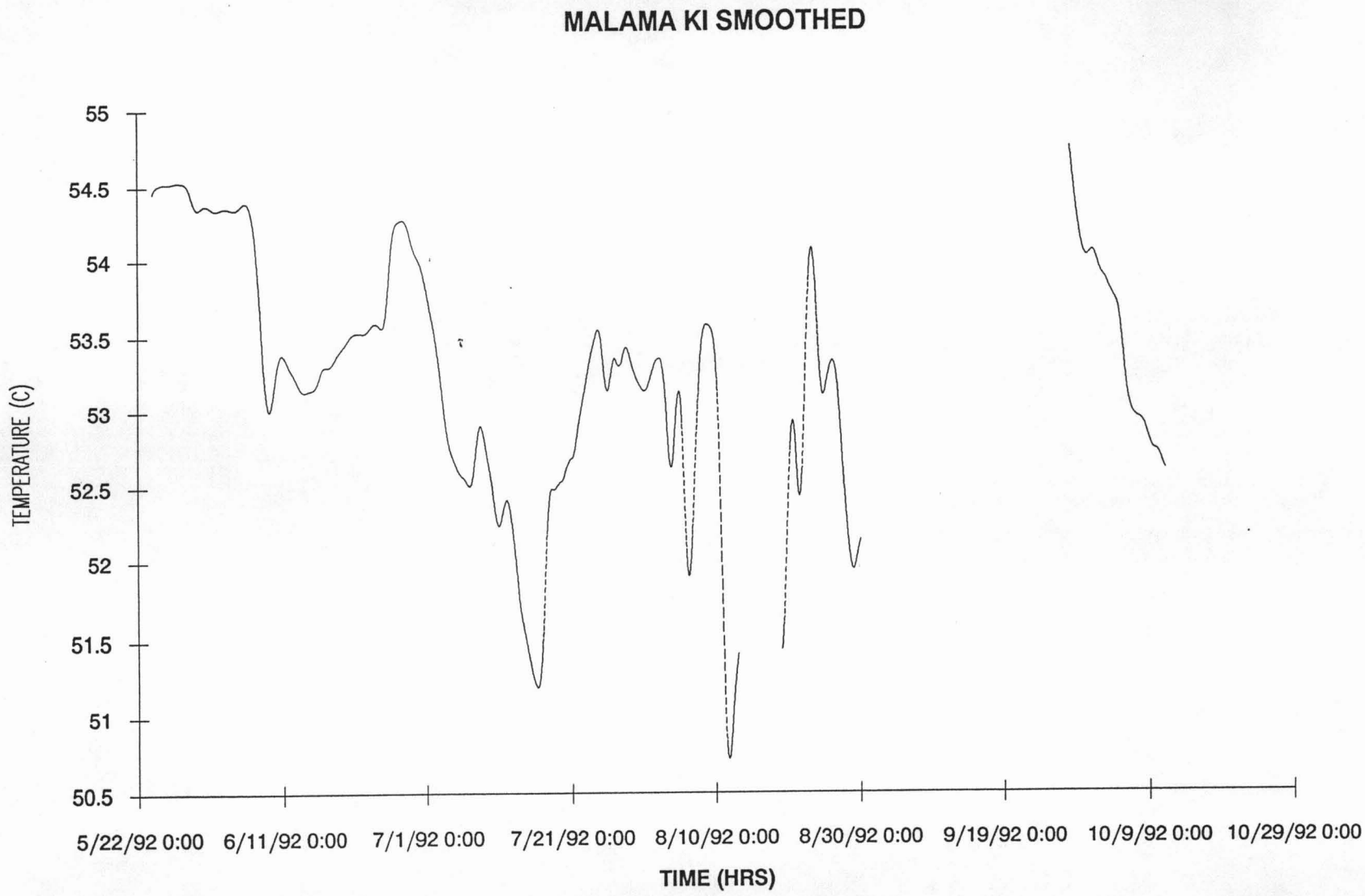


Figure 3. Groundwater temperature variations recorded in the Malama Ki well during monitoring interval.

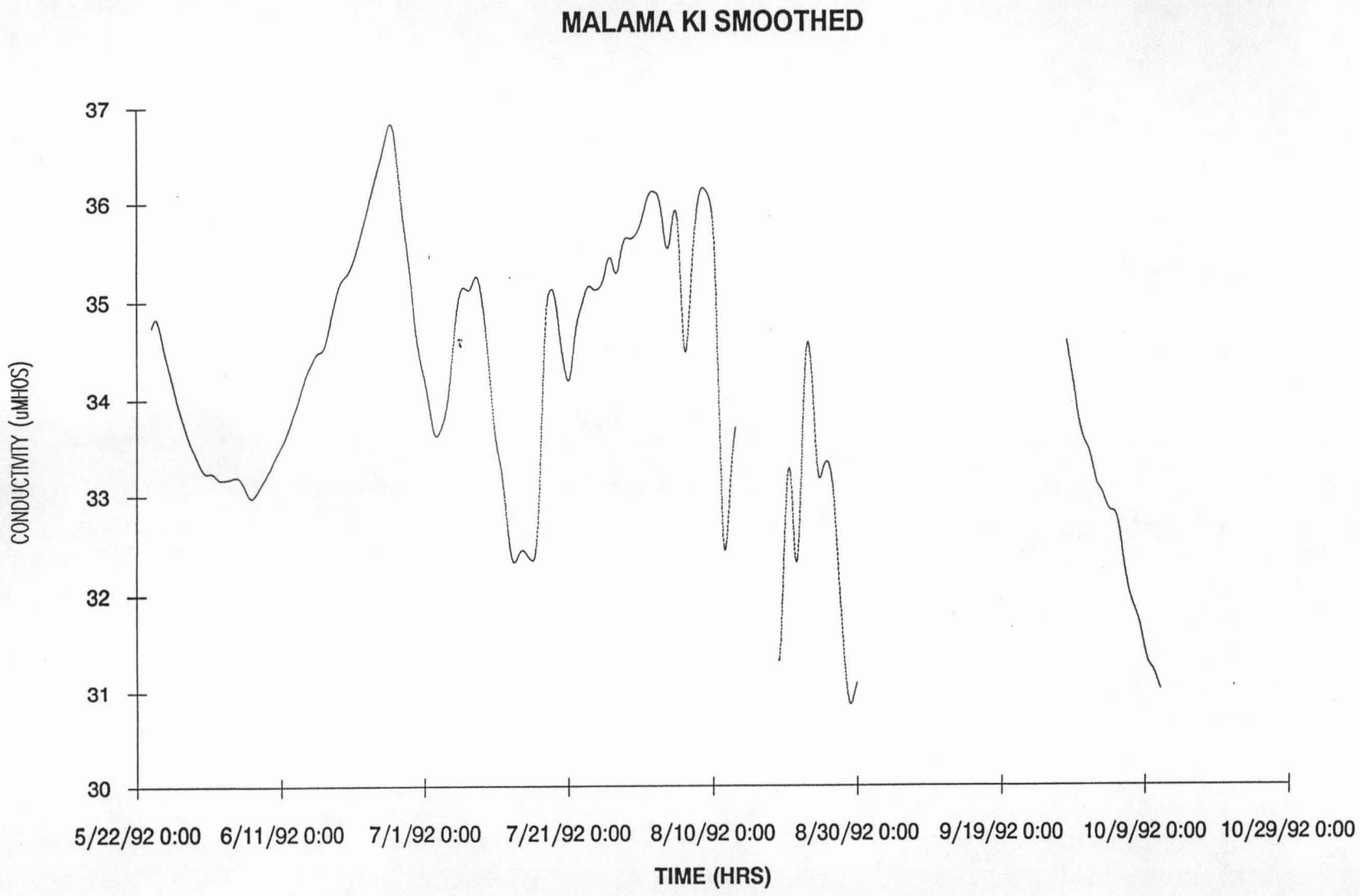


Figure 4. Groundwater conductivity variations recorded in the Malama Ki well during monitoring interval.

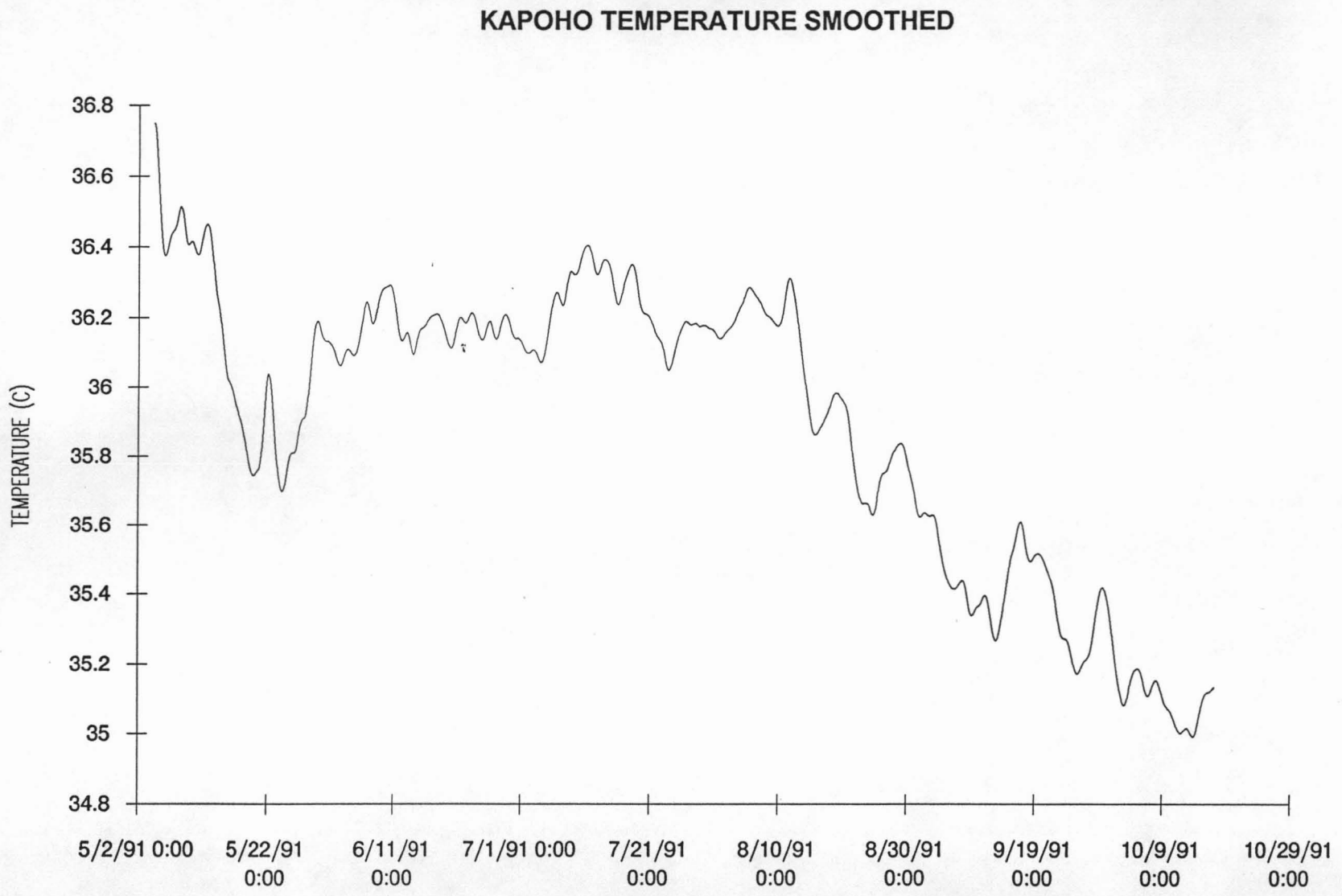


Figure 5. Groundwater temperature variations recorded in the Kapoho Airstrip well during monitoring interval.

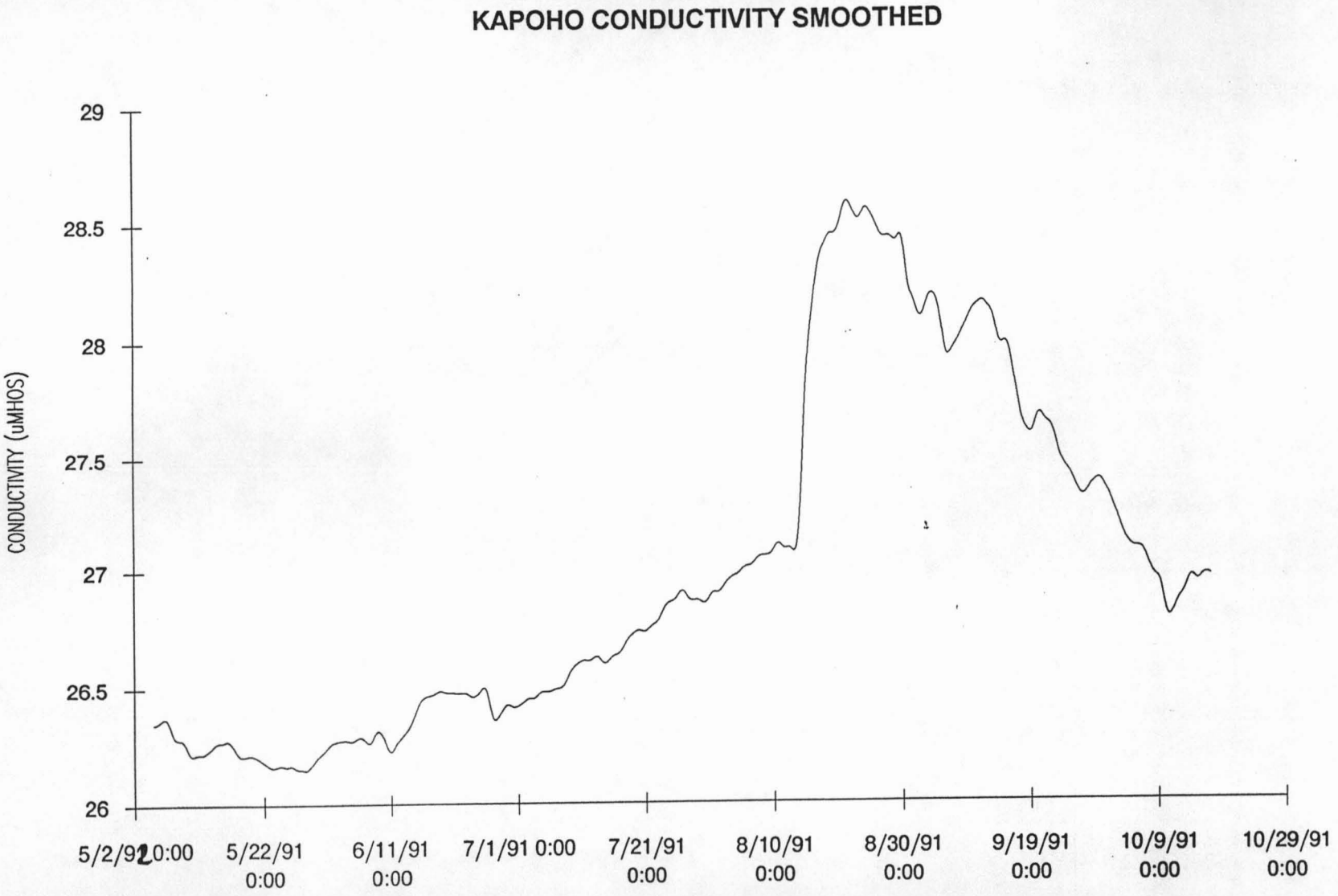


Figure 6. Groundwater conductivity variations recorded in the Kapoho Airstrip well during monitoring interval.

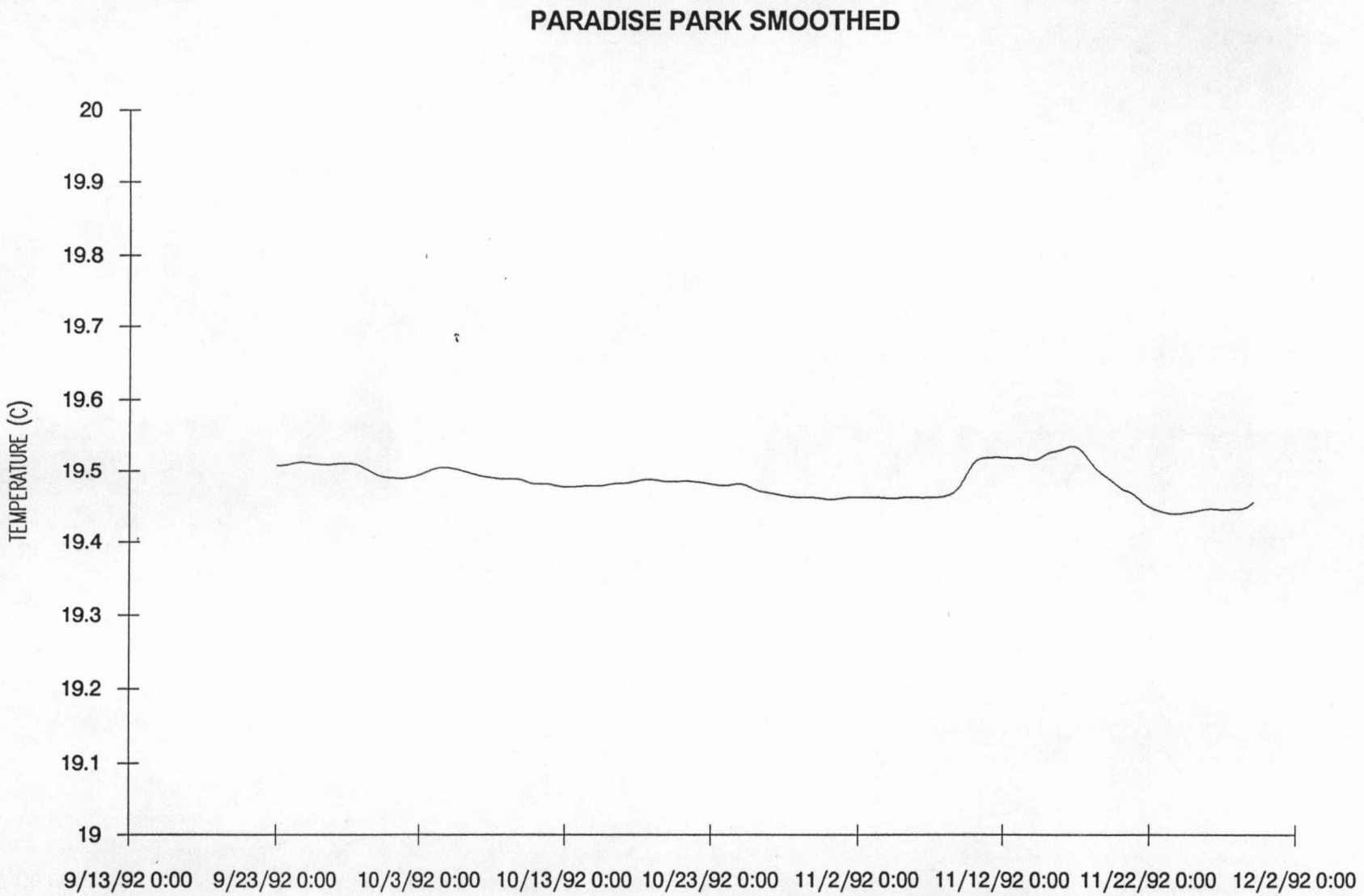


Figure 7. Groundwater temperature variations recorded in the Paradise Park well during monitoring interval.

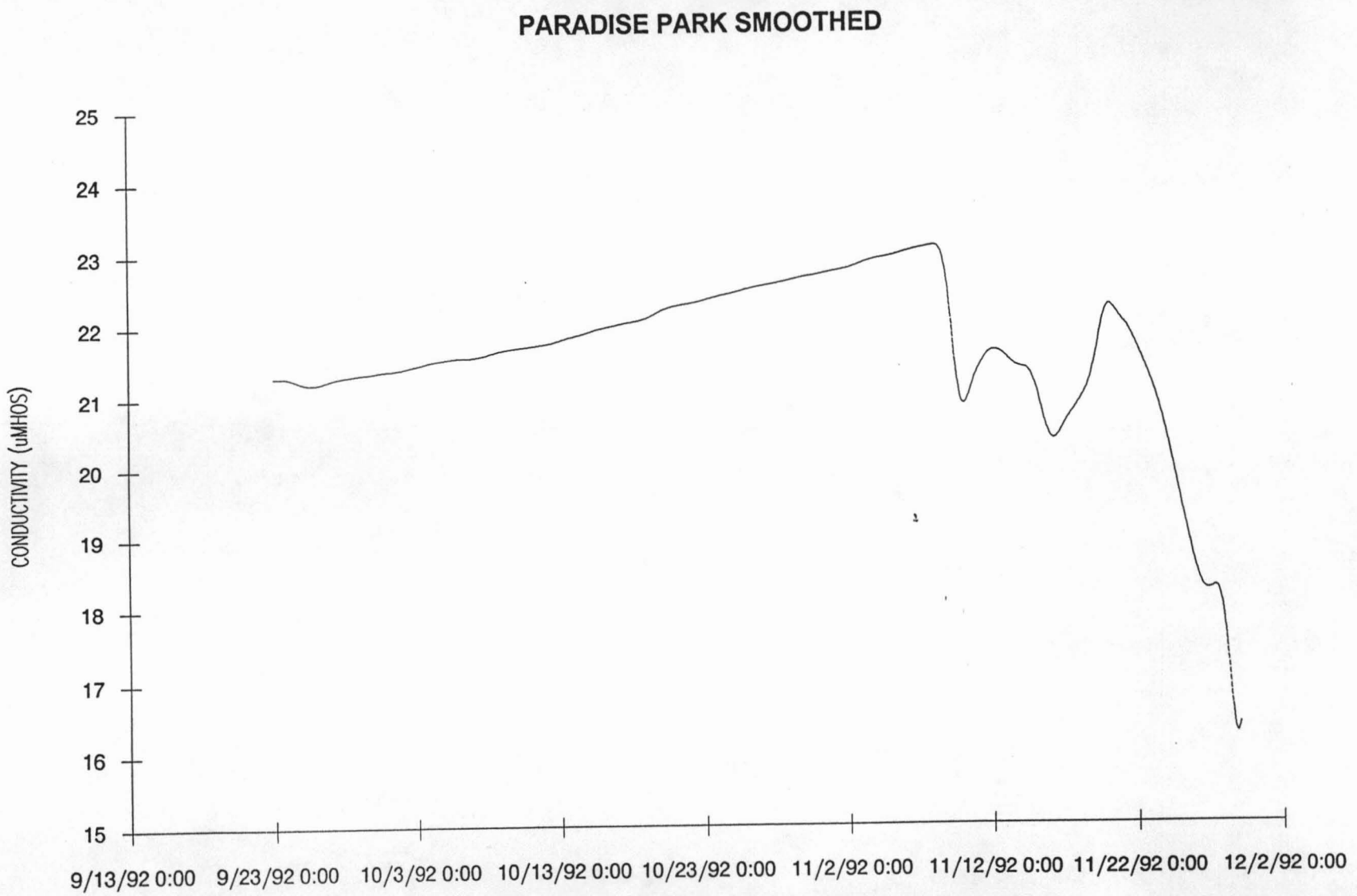


Figure 8. Groundwater conductivity variations recorded in the Paradise Park well during monitoring interval.

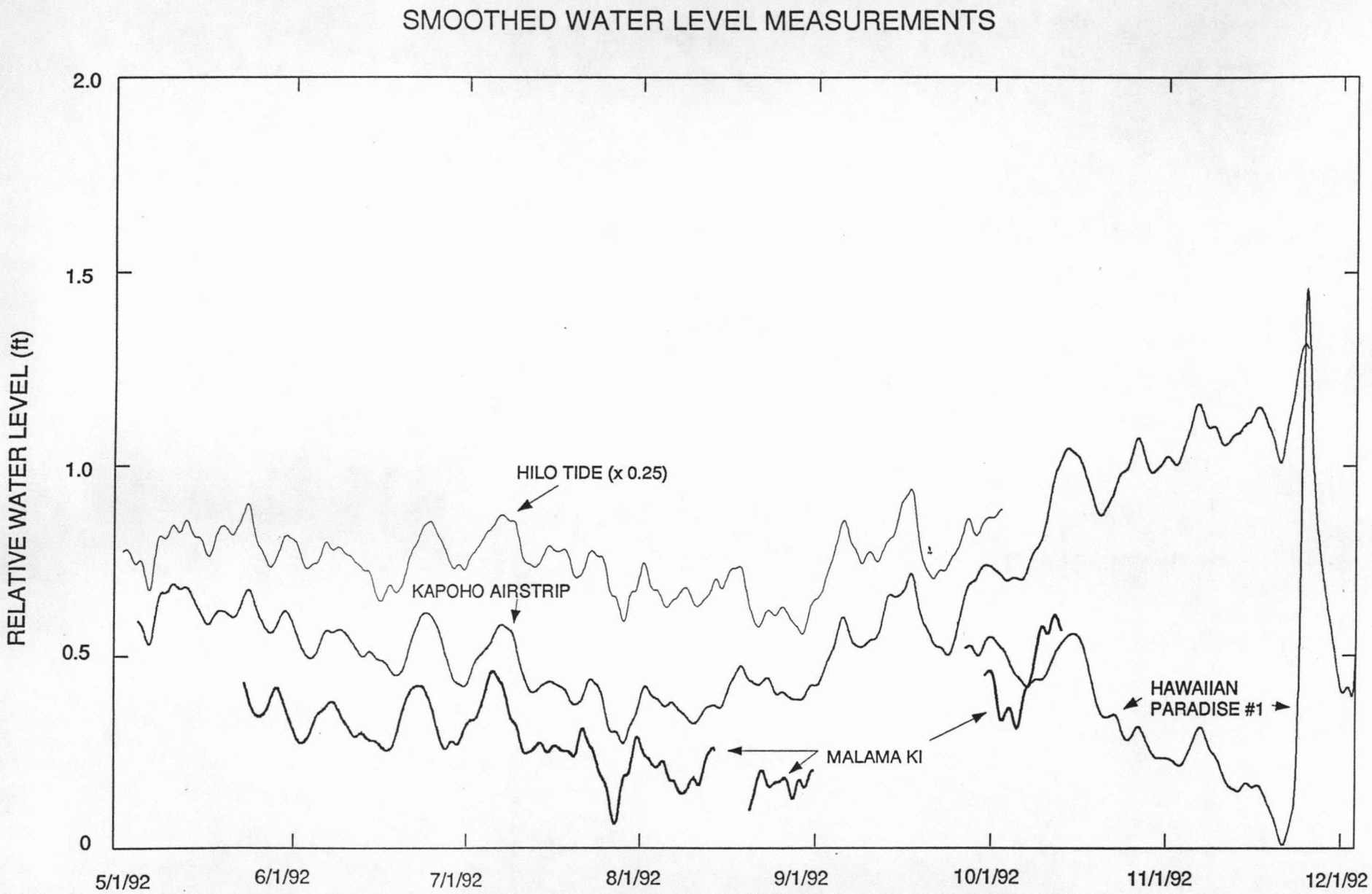


Figure 8. Groundwater level variations recorded in the Malama Ki, Kapoho Airstrip, and Paradise Park wells during monitoring interval. Also shown is a tide gauge record, reduced by four times, for Hilo harbor.

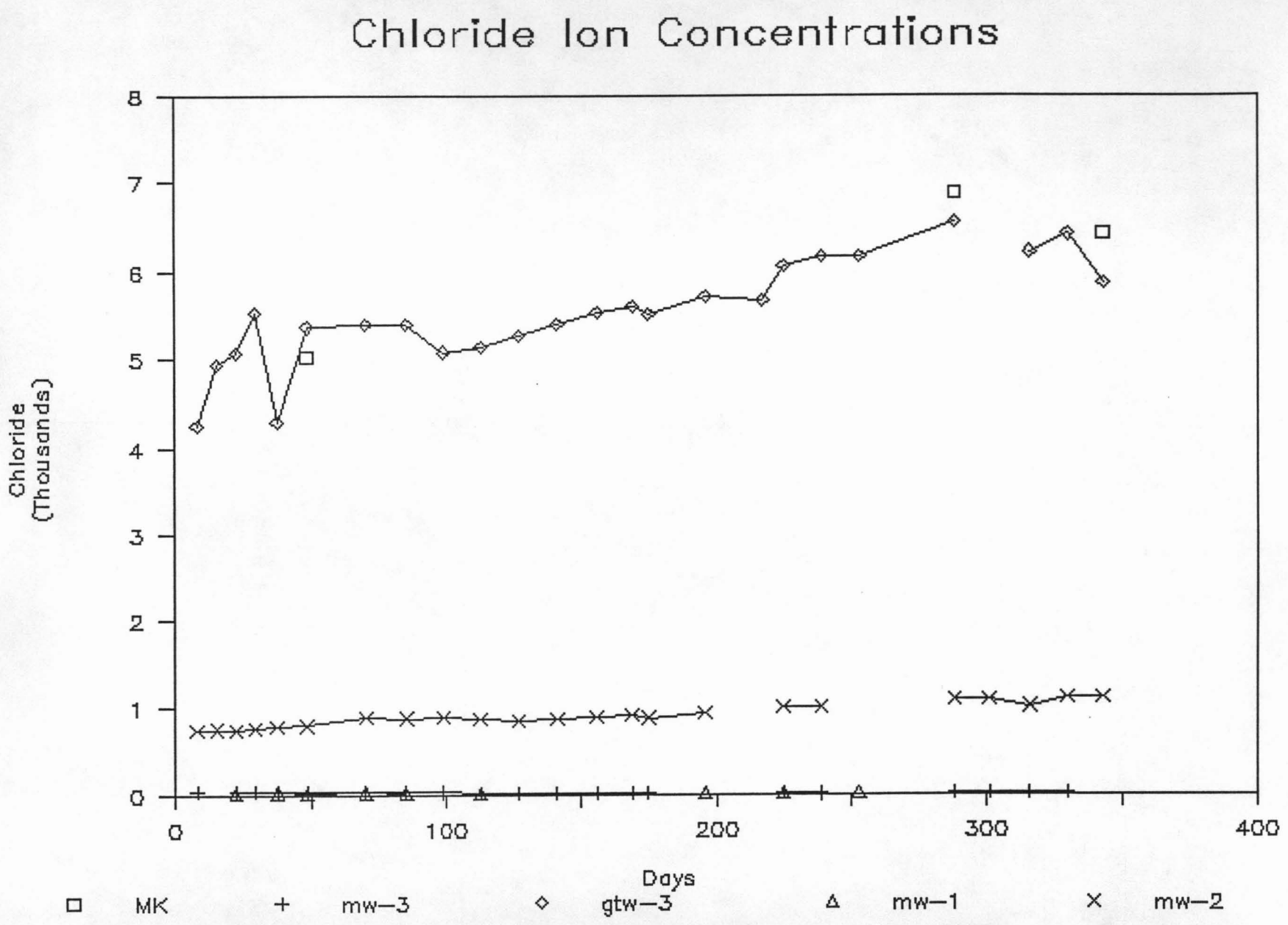


Figure 9. Plot of the chloride concentrations found in the intermittent sampling program for the Malama Ki (MK), the PGV Monitoring Well 3 (MW-3), Geothermal Test Well 3 (GTW-3), and PGV Monitoring Wells 1 and 2 (MW-1, MW-2).

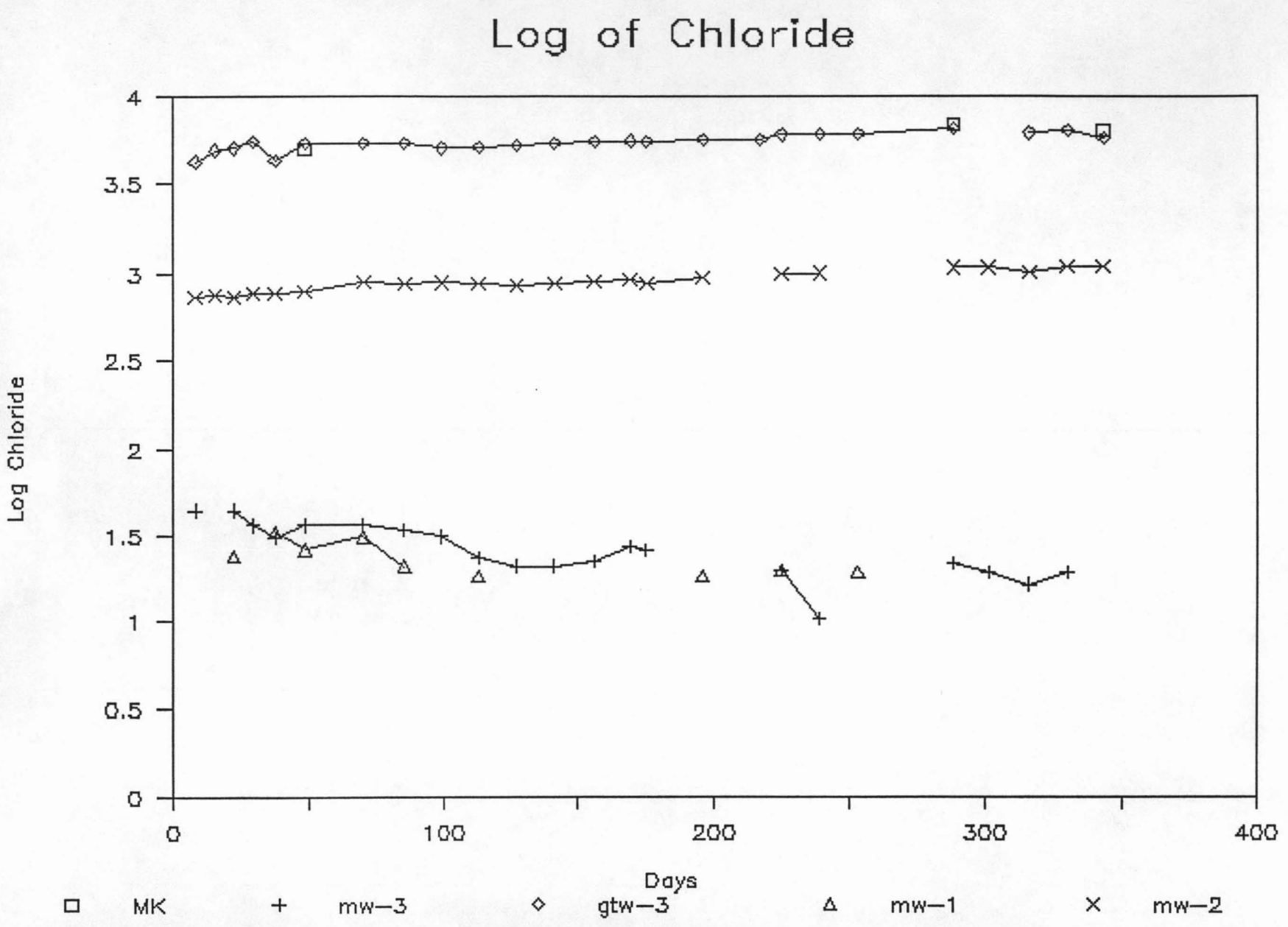


Figure 10. Plot of the log of chloride concentrations for wells presented in Figure 9 to show variations in the low chloride wells.

FILENAME:Kawai6549-03

SUBJECT:WELL CHEMISTRY FOR SELECTED GROUNDWATER WELLS

WELL: Kawaihae Exploration Well No. 6549-03

SAMPLING DATA

/wcs DATE COLLECT	TIME (DAY)	FLOW RATE (gpm)	TEMP@ COLLEC ^C	AVG.pH @COLLEC -TION
1 07/06/92	13:05	706	28.4	7.88
1 07/06/92	16:00	700	28.4	7.91
2 07/07/92	11:00	700		na
3 07/08/92	11:00	702	28.3	7.66
3 07/08/92	13:00	702	28.4	7.81
4 07/09/92	11:00	349.7	29.1	7.77
4 07/09/92	12:00	347.2	29.2	7.79

Cation ELEMENTS

DATE COLLECT	pH @ 25 ^C	Li mg/L	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	SiO2 mg/L
1 07/06/92		<0.1	90.4	9.79	19.6	19.3	66.9
1 07/06/92			88.4		18.9	19	64.8
2 07/07/92		<0.1	88.7	9.79	19.4	19	63.9
3 07/08/92		<0.1	91.9	10.4	20.6	20.2	64.6
3 07/08/92			92.8		20.7	20.5	64.8
4 07/09/92			92.8		20.6	20.5	65.9
4 07/09/92			94.6		21	20.9	65.5

RESULT OF ANION ANALYSIS

DATE COLLECT	CHLORI mgCl/	F mg/L	Br mg/L	ALKALINITY mgCaC per L	SO4 mg/L	NO3 mg/L	PO4 mg/L
1 07/06/92	187	0.245	1.57	45	42.7	4.95	
1 07/06/92	190			45.1			
2 07/07/92	194	0.216	0.903	47.8	43.01	4.8	
3 07/08/92	206	0.43	1	47	46.2	4.86	
3 07/08/92	205	0.236	1.11		46.4	5.12	
4 07/09/92	214	0.435	1	48.6	46.7	4.88	
4 07/09/92	207	0.212	0.97	47.5	47.1	4.49	

Li meq/	Na meq/	K meq/	Ca meq/	Mg meq/	Total Cation meq/	Total Anion meq/L	Ion Balance meq/l	Ion Balance percent
	3.93	0.25	0.98	1.59	6.75	5.27	1.47	12.26
	3.85	0.00	0.94	1.56	6.35	6.26	0.09	0.72
	3.86	0.25	0.97	1.56	6.64	6.43	0.21	1.63
	4.00	0.27	1.03	1.66	6.95	6.75	0.20	1.49
	4.04	0.00	1.03	1.69	6.76	5.78	0.97	7.77
	4.04	0.00	1.03	1.69	6.75	7.01	-0.26	-1.86
	4.11	0.00	1.05	1.72	6.88	6.79	0.09	0.69

CL meq/L	F meq/L	BR meq/L	ALKALI meq/L	SO4 meq/L	NO3 meq/L	PO4 meq/L	Total Anions meq/L
5.27	0.01	0.04	0.90	2.41	0.08	0.00	5.27
5.36	0.00	0.00	0.90	0.00	0.00	0.00	6.26
5.47	0.01	0.03	0.96	2.43	0.08	0.00	6.43
5.81	0.01	0.03	0.94	2.61	0.08	0.00	6.75
5.78	0.01	0.03	0.00	2.62	0.08	0.00	5.78
6.04	0.01	0.03	0.97	2.63	0.08	0.00	7.01
5.84	0.01	0.03	0.95	2.66	0.07	0.00	6.79

TRACE ELEMENTS Kawaihae Exploration Well No. 6549-03

	DATE COLLECT	Al ug/L	B ug/L	Ba mg/L	Cd ug/L	Cu ug/L	Fe mg/L	Mn mg/L	Ni mg/L
1	07/06/92	<0.5	<0.5	<1.0	<0.5	<0.5	0.229	<0.5	<1.0
2	07/07/92	<0.5	<0.5	<1.0	<0.5	<0.5	0.246	<0.5	<1.0
3	07/08/92	<0.5	<0.5	<1.0	<0.5	<0.5	0.207	<0.5	<1.0

		Pb ug/L	Sr mg/L	Zn ug/L
1	07/06/92	<2.0	0.113	<0.5
2	07/07/92	<2.0	0.092	<0.5
3	07/08/92	<2.0	0.106	<0.5